## REMARKS

Claims 1-8 and 66-67 were previously presented for examination. Pursuant to the Final Office Action dated October 4, 2006, and the undersigned's telephone interview with Examiner Lo on October 12, 2006, claims 1-8 are presented herewith. Claims 1-2 are currently amended. Claims 3-6 are as originally presented. Claims 7-8 were previously presented. Claims 66-67 are canceled.

Support for amended claims 1 and 2 is provided, for example, on page 9, lines 23-30, page 11, lines 4-5 and page 20, lines 19-20; page 4, lines 4-11 and page 28, lines 2-21; and page 31, line 19 through page 32, lines 26-30. Applicant affirms that no new matter has been added to the patent application. Applicant thanks the Examiner for granting the aforementioned telephone interview and hereby requests careful reconsideration of this application in view of the following comments.

### RESPONSE TO 35 U.S.C. § 101 REJECTION

**Claims 66-67**

The Examiner rejected claims 66-67 under 35 U.S.C. § 101 as being directed to non-statutory subject matter. Applicant hereby requests withdrawal of this rejection since claims 66-67 have been canceled. Thus, the subject matter rejected by the Examiner is no longer recited in the claims.

### RESPONSE TO 35 U.S.C. § 112 REJECTIONS

**Claims 1-8 and 66-67**

The Examiner rejected claims 1-8 and 66-67 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. The term "non-stochastic" has been stricken from the preamble of independent claims 1 and 2. Applicant respectfully requests withdrawal of the § 112 rejection in view of the foregoing comments and revisions to the claims.

### RESPONSE TO 35 U.S.C. § 102 AND § 103 REJECTIONS

**Claims 1-8 and 66-67**

The Examiner rejected claims 1-6 and 66-67 under 35 U.S.C. § 102(e) as being anticipated by Caflisch, et al. (US 6,714,620). Claims 7-8 were rejected under 35 U.S.C. §103(a) as being unpatentable over Caflisch, et al. (US 6,714,620) in view of Llinas, et al. (US 2003/0144432 A1). Applicant respectfully requests withdrawal of the § 102 and § 103 rejections since Applicant has canceled claims 66 and 67. Notably, independent claims 1 and 2 recite novel physical subject matter pertaining to, in combination: (a) *invariant imbedding*; (b) *transforming a boundary-value problem*; and (c) *supercritical, critical and subcritical particle multiplication.* These and other features of Applicant's invention explicitly distinguish the invention from Caflisch and Llinas, both singularly and in combination.

**(A) Invariant Imbedding**

Caflisch fails to disclose, teach, or fairly suggest the use of a direct, non-stochastic computational method. Caflisch instead describes the stochastic (non-deterministic) generation of particles "chosen at random by sampling." The present invention discloses a process that allows for pre-processing of generalized information without the requirement of foreknowledge of where the focus of radiation or initial distribution of radiation may be. Further, the present invention does not require any specification as to the generation of radiation once it is a simple initial value within the imbedded invariant context.

An initial value problem as described by the present invention is fundamentally different from those discussed by the Examiner in that rather than using scoring tallies for superposition and solution construction, the asserted references use transport multipliers that are tightly bound in time epochs (collision moments). This effectively relaxes boundary conditions.

For instance, one can use a partial current rather than a net current boundary condition. These time epochs relate to a physical quality that is geometrically and somewhat materially invariant, and hence are restricted in terms of time, but can be solved iteratively with initialization in terms of space. Such invariance is relaxed in the present invention (*see* page 31, lines 27-28 of patent application). The present invention is a fundamentally different approach to the solution of transport problems stochastically as well as to the solution of transport problems that retain the normal global time formalisms—for example, the Boltzmann Transport Equation ("BTE") and its myriad derivatives. An invariant imbedded technique is neither statistical (though data may be derived statistically) nor a direct means of solving the BTE.

As described in the present application, the mechanism of the invention uses an iterative process to reconstruct the full time integrated result associated with time epoch differentiated radiation transport interaction events. The initial value nature of the solution allows one to specify a plurality of initial value points without running out of memory. In the present invention, one must pay close attention to the restricted definitions of Integration Kernels and Transport Multipliers that fit into the imbedded invariant conceptual context. These are clearly restricted in time or generation or scattering moment, although acceleration in certain contexts (problem specific) can occur. These multipliers are clearly distinguished from final scoring tallies, in contrast to Caflisch. In order to accumulate interaction tallies in the present invention, one must run an iterative calculation with a separate and distinct interaction model (Fig. 7 Block 5).

The present invention is solved in two separable phases. The first phase requires minimal or no foreknowledge of how particles will initially be distributed in the system. In subsequent solution phases, very fast solutions are created from any number of initial conditions, allowing multiple what-if scenarios. In this fashion, the present invention provides a practical multidimensional method for "Invariant Imbedding" through the use of computer memory.

The initial conditions with regard to beamlets in Caflisch require a thorough, total, and time epoch global or integral particle distribution description resulting in a particle distribution. In the present invention, the collision moments of source particles are separate, and hence each requires far less memory than any process disclosed in Caflisch. Considerable information regarding initial particle position and distribution of a plurality of particles is required in Caflisch. Caflisch clearly relies on stochastic methodology or pencil beam, as described in the '620 patent at column 27, lines 14-24. Thus, there is no basis for comparing this methodology with the present invention, which teaches away from Caflisch.

The nature of initial values and defined scattering epochs in the present invention greatly reduces its storage requirements and its setup time (*see* Fig. 17 Monte Carlo comparison). Moreover, the present invention advantageously avoids errors associated with stochastic variance. Further advantages of the subject invention over Caflisch include distributed error control, initial value setup processing that enables fast evaluation of "what-if" scenarios with arbitrary initial beam or radiation distribution scenarios, the ability to make changes to material

compositions while fairly accounting for the change in final answers, and the ability to use the present invention with comparatively smaller machines.

It would not have been obvious to modify Caflisch's non-deterministic process in accordance with Applicant's direct, non-stochastic computational algorithm, as defined in amended claims 1 and 2. Doing so would be entirely counter to the stated intentions and process design requirements of Caflisch to generate final particle tallies relating to dose distribution from beamlets, in a random manner.

Step (d) of Applicant's claims 1 and 2 has been modified to clarify that the instant method includes the step of: "using said ray sets and appropriate integration kernel to determine *invariant imbedding* transport multipliers *or direct collision moment transport multipliers.*" Applicant respectfully requests withdrawal of the § 102 and § 103 rejections in view of the foregoing comments and revisions to the claims.

**(B) Transforming a Boundary-Value Problem**

The present invention transforms a traditional boundary-value problem to an initial-value problem. A boundary value problem is a mathematical problem in which conditions at geometric spatial boundaries are fully specified (such as beamlets in Caflisch) and transport occurs globally bounded in time until such time as all or most particle scores are tallied (as in Caflisch—the final tally dose distribution). Such designs can superimpose tallied results to directly obtain a final particle distribution from "pencil beam" methods in various schemes.

Such superposition occurs in one step, or in the case of a Green's function, often occurs simultaneously with the generation of a solution in an input->process->output paradigm while tightly constrained to the boundary-value global solution. The use of superposition as a one-step, rapid process that is not disclosed or suggested by Caflisch. Rather, Caflisch relies on Monte Carlo to provide input data for a fast pencil beam computation that is known in the art as "superposition." The present invention discloses a process that allows for pre-processing of generalized information without the requirement of foreknowledge of where the focus of radiation or initial distribution of radiation may be. Further, the present invention does not require any specification as to the generation of radiation once it is a simple initial value within the imbedded invariant context.

Step (d) of Applicant's claims 1 and 2 has been modified to clarify that the instant method includes: "using said ray sets and appropriate integration kernel to determine *invariant imbedding* transport multipliers *or direct collision moment transport multipliers.*" In the aforementioned phrase, the terms "invariant imbedding" and "direct collision moment" refer to the specific methodology whereby the instant invention transforms a traditional boundary-value problem to an initial-value problem within the iterative context of steps (f-h) in claim 1 and steps (f-g) in claim 2. Therefore, Applicant respectfully requests withdrawal of the § 102 and § 103 rejections in view of the foregoing comments and revisions to the claims.

**(C) Particle Multiplication**

If one were to apply Caflisch and Llinas to a problem involving critical or supercritical particle multiplication (e.g., traditional Sturm-Louiville in a nuclear reactor), the methods of Caflisch and Llinas, singularly and in combination, would fundamentally not work. This is because Caflisch and Llinas do not distinguish time epochs and/or collision moments to attain Invariant Imbedding properties. Where would one attain the initial particle distributions in Caflisch? Caflisch describes specific sampling. As such, there is nothing to measure or adjust; thus the transport multipliers of Caflisch are meaningless, because they are overwhelmed by a critical or supercritical system.

Conversely, in the present invention, one simply applies the defined criteria for a transport multiplier to, for example, the absorption and fission processes as invariant collision moments. Scatter, especially fast neutrons within a reactor, is usually unaffected by multiplication (ratio of U235/U238, e.g., in a uranium fueled nuclear reactor). The present invention is fully operable with critical and supercritical systems because the boundary of time is thorough in the transport multiplier, and time epoch results are accumulated naturally as part of the iteration scheme.

Steps (i) and (h) of Applicant's claims 1 and 2, respectively, have been modified to clarify that the instant method includes: "repeating steps ... until interaction reaction rates and/or the generational *supercritical, critical or subcritical* Eigenvalue substantially converge." Therefore, Applicant respectfully requests withdrawal of the § 102 and § 103 rejections in view of the foregoing comments and revisions to the claims.

## CONCLUSION

Applicant's claims 1 and 2 recite novel physical subject matter pertaining to, *inter alia*: (a) invariant imbedding; (b) transforming a boundary-value problem; and (c) supercritical, critical and subcritical particle multiplication. The stated intentions and design requirements of Caflisch (US 6,714,620) and Llinas (US 2003/0144432), singularly and in combination, expressly teach away from Applicant's invention, as claimed. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, ... would be led in a direction divergent from the path that was taken by the applicant." *Tec Air, Inc. v. Denso Mfg. Mich. Inc.*, 192 F.3d 1353, 1360 (Fed. Cir. 1999). Applicant's invention reveals a new and unexpected principle of operation that is not taught, disclosed or in any way suggested by Caflisch, Llinas or any combination thereof. The novel features of Applicant's invention which effect this new principle of operation are clearly recited in Applicant's pending claims 1-8; whereas, the asserted references lack any suggestion that the inventions should be modified in a manner that meets the limitations of Applicant's claims.

Applicant has amended the claims of the present application so that they are proper, definite, and define novel structure which is also nonobvious. Therefore, Applicant submits that independent claims 1 and 2 should be indicated allowed. Dependent claims 3-8 include all the limitations of the base claims and therefore define patentably over the prior art. For all of these reasons, Applicant respectfully requests withdrawal of the § 101, § 112, § 102 and § 103 rejections.

Applicant believes all of the presently pending claims are in condition for allowance. Accordingly, entry and careful consideration of this Response and an early indication of allowance is hereby requested. If the Examiner believes there is any issue that could be resolved by a telephone conference or a personal interview, the Examiner is respectfully requested to contact the undersigned at the telephone number listed below.

Respectfully submitted,

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By: _____

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